Ground Water Pollution in the Lower Yakima Valley and Methemoglobinemia

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FRIENDS OF TOPPENISH CREEK

This presentation on Nitrates and Nitrites is designed for public and private health care providers and students in the health professions. Up to 20% or private wells in the lower Yakima Valley have elevated levels of nitrates and nitrites. Therefore, the information is important when educating the public and when delivering health care to this population.

2012 Joint Conference on Health

Presentation Disclosure

No off label, experimental or investigational use of medications are discussed during this presentation

Friends of Toppenish Creek has no interests of commercial services, products or support that requires disclosure

Learning Objectives

- Participants will described the etiologies for methemoglobinemia in humans
- Participants will list the causes for elevated levels of nitrates and nitrites in water supplies
- Participants will describe the risk factors for methemoglobinemia
- Participants will be able to administer appropriate treatments for contaminated water and for methemoglobinemia

Inherited Methemoglobinemia

The Martin Fugate Family. Retrieved from http://www.secrethistoryx.com/tag/methemoglobinemia/

This is a picture of a famous family, the Fugates, whose skin appears blue due to inherited methemoglobinemia. The family and relatives lived in Appalachia during the 1800's. Some members were carriers for a recessive gene that prevents production of an enzyme, cytochrome b5 reductase, needed to break down methemoglobin. Excessive levels of methemoglobin turn the blood chocolate brown and the skin bluish in color. Intermarriage among clans in the Kentucky hills resulted in children with the condition. Although stories abounded for many years about the mysterious blue people, the family resisted interviews and rarely sought medical care. It is reported that blue members of the family and relatives lived into their 80's and 90's. Many only turned blue when stressed. In 1982 a blue baby, Benjy was born and rushed to a hospital where physicians determined the cause and resurrected the legend. The child's skin turned pink with administration of methylene blue, a compound that functions like the missing enzyme. Sadly, the unwanted fame drove the family away from the Kentucky hills and the demeaning attention. This picture was obtained from a public post by a descendent. Methemoglobinemia is an extreme symptom that may also result from nitrate contamination of drinking water. It is termed blue baby syndrome in the media.

Sources:

Secret History X (nd) The Martin Fugate Family. Retrieved from http://www.secrethistoryx.com/tag/methemoglobinemia/

Word Press (nd) Kentucky Blue People. Retrieved from http://kentuckybluepeople.wordpress.com/the-fugate-family-paige-disponette/

Description - Methemoglobinemia

Hemoglobin in our Red Blood Cells (RBCs) carries oxygen from the lungs to the tissues. Iron in the hemoglobin is normally in a ferrous (Fe 2+) state. If the iron is oxidized to a ferric (Fe3+) state it can no longer carry oxygen. Chemicals that can oxidize Fe 2+ to Fe 3+ include:

- **Nitrites - Methemoglobinemia**
- Carbon Monoxide – Carboxyhemoglobinemia
- Hydrogen Sulfide - Sulfhemoglobinemia

Clinical Appearance - Methemoglobinemia

- S/S appear with Methemoglobin blood levels > 10%
- Cyanosis – Bluish skin and lips
- Shortness of Breath
- Mental Status Changes
- Nausea, Vomiting, Diarrhea
- Headache, Dizziness
- Severe symptoms occur with levels > 50%
- Dysrhythmias, seizures, coma, circulatory collapse
- Death with levels > 70%

Congenital Methemoglobinemia

- Relates to deficiencies in the enzyme – Nicotinamide adenine dinucleotide plus hydrogen (NADH) which reduces methemoglobin back to normal hemoglobin
- To a lesser extent deficiencies in the enzyme Nicotinamide adenine dinucleotide phosphate (NADPH) cause problems
- Metabolic defects such as PKU, G6PD that impair synthesis and utilization of NADH & NADPH predispose individuals to methemoglobinemia
- In Yakima County, with around 4,000 births per year, there are 2 to 8 cases of congenital disorders of metabolism such as PKU, adrenal or thyroid problems every year

In G6PD there is a deficiency of NADPH. In PKU there is a deficiency of NADH. Yakima County is intensely agricultural and we have risk factors from pesticides, insecticides and herbicides as well as nitrates in the water. Most of the metabolic defects that occurred here in recent years involved the thyroid and adrenal glands.

Acquired Methemoglobinemia

- Occurs when the body's mechanisms to convert methemoglobin back to hemoglobin are overwhelmed
- Oxidizing drugs such as benzocaine, dapsone & nitrates accelerate the production of methemoglobin up to 1,000 times normal
- Any condition that converts nitrates (NO_3) into nitrites (NO_2) will predispose a person to methemoglobinemia
- ***Nitrite*** *converts hemoglobin into methemoglobin*

Causes of Methemoglobinemia

- Increased intake of nitrates and nitrites
  a. Vegetables: broccoli, collards, root vegetables
  b. Water
  c. Food Preservatives such as sodium nitrite
  d. Drugs such as nitrates and topical anesthetics
- Increased conversion of nitrate to nitrite
  a. Bacteria in the mouth and stomach
  b. Increased pH in stomach favors bacterial growth
  c. Achlorhydrea – Decreased stomach acid
  d. Impaired NADH or NADPH
  e. Gastric inflammation

Vegetables constitute about 70% of the nitrate in the human diet. The mean intake of nitrate – n in the U.S. is about 40 to 100 mg per day. In Europe this number is higher, 50 to 140 especially in Eastern Europe where people eat lots of vegetables. Some vegetarians take in over 300 mg per day with no ill effects, presumable due to the protective effects of vitamins

Why Are Babies Most Affected?

- They have high levels of fetal hemoglobin which is more easily oxidized to methemoglobin
- Higher intestinal pH enhances conversion of nitrate to nitrite
- Their intestinal flora is more likely to change nitrates to nitrites
- NADH is only half as active in young infants

How Much Nitrate is Acceptable?

- An Oral Reference Dose (RfD)is defined as "an estimate, with uncertainty spanning perhaps an order of magnitude, of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime."
- The RfD for Nitrate – N is 1.6 mg/kg/day.
- Please note that Nitrate – N includes only the nitrogen in the nitrate (NO_3) molecule.

Role of Nitrate in Water

- A normal adult weighing 100 kg (220 pounds) has an RfD of 160 mg Nitrate - Nitrogen
- He/she may consume 3,000 ml of water per day.
- If the water contains 5 mg/L of Nitrate - N then he/she takes in 15 mg of Nitrate – Nitrogen
- If the water contains 10 mg/L then he/she takes in 30 mg of Nitrate – Nitrogen
- If the water contains 50 mg/L then he/she takes in 150 mg of Nitrate - Nitrogen

In the U.S. normal intake for adults is 40 to 100 mg per day. In Europe the normal intake is 50 to 140 mg/day

Role of Nitrate in Water

- A baby weighing 5 kg (11 pounds) has an RfD of 8 mg Nitrate - Nitrogen
- He/she may consume 800 ml of formula per day.
- If the water used for reconstituting formula contains 5 mg/L of Nitrate - N then baby takes in 4 mg of Nitrate – Nitrogen
- If the water contains 10 mg/L then baby takes in 8 mg of Nitrate – Nitrogen
- If the water contains 50 mg/L then baby takes in 40 mg of Nitrate - Nitrogen

http://babyheartblog.org/2010/07/16/blue-babies-bombs-and-bad-places/

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A Case Study

"A two month old female infant is brought to your clinic in a rural area for a routine well baby checkup. According to the child's chart, she was delivered two weeks early because of maternal toxemia. There was no neonatal distress; her birth weight was 7 pounds and 2 ounces"

Agency for Toxic Substances and Disease Registry. (2001). *Case Studies in Environmental Medicine Nitrate/Nitrite Toxicity.* Department of Health & Human Services. Atlanta, GA. Retrieved from http://www.atsdr.cdc.gov/csem/nitrate/docs/nitrate_nitrite.pdf

This Case Study is adapted from a self study module provided by the Agency for Toxic Substances and Disease Registry. I have taken the liberty of cutting and pasting portions of the program here for our use. Continuing education credits from self study were available until 2010.

The module can be accessed at http://www.atsdr.cdc.gov/csem/nitrate/docs/nitrate_nitrite.pdf

A Case Study

- "Today the mother states that she has noticed an intermittent bluish discoloration of the baby's lips, tip of the nose, and ears. Physical examination of the infant is negative for cardiac murmurs and abnormalities on lung auscultation. You notice a below average weight gain. Feedings consist of 4 ounces (120 ml) of diluted formula every two hours.
- The infant has occasional loose stools. You instruct the parents to increase caloric feedings, which include vitamin and mineral supplements. You tell the parents to call immediately if any further episodes of the bluish coloration occur."

A Case Study

- "Approximately three weeks later, the baby's frantic parents call your office; the infant is crying incessantly and has vomiting and profuse diarrhea.
- When the baby is brought to your clinic a few minutes later, she is afebrile but has tachypnea, central cyanosis, and drowsiness.
- Vital Signs are:
  - BP – 78/30 (mid normal is 80/46)
  - Heart rate – 140 beats per minute
  - Respirations – 40 breaths per minute"

A Case Study

- "An ambulance is summoned. 100% oxygen is administered by face mask. No improvement in the cyanosis is noted on her arrival at the hospital emergency room.
- The examining emergency physician now notes a II/VI systolic murmur and central cyanosis, which has not improved despite administration of 100% oxygen for nearly one hour. No evidence of cardiac failure, atelectasis, pneumonia, or pneumothorax.
- Therapy with methylene blue is started, which results in dramatic resolution of the cyanosis.

Methylene blue increases the NADPH route of conversion of methemoglobin to hemoglobin.

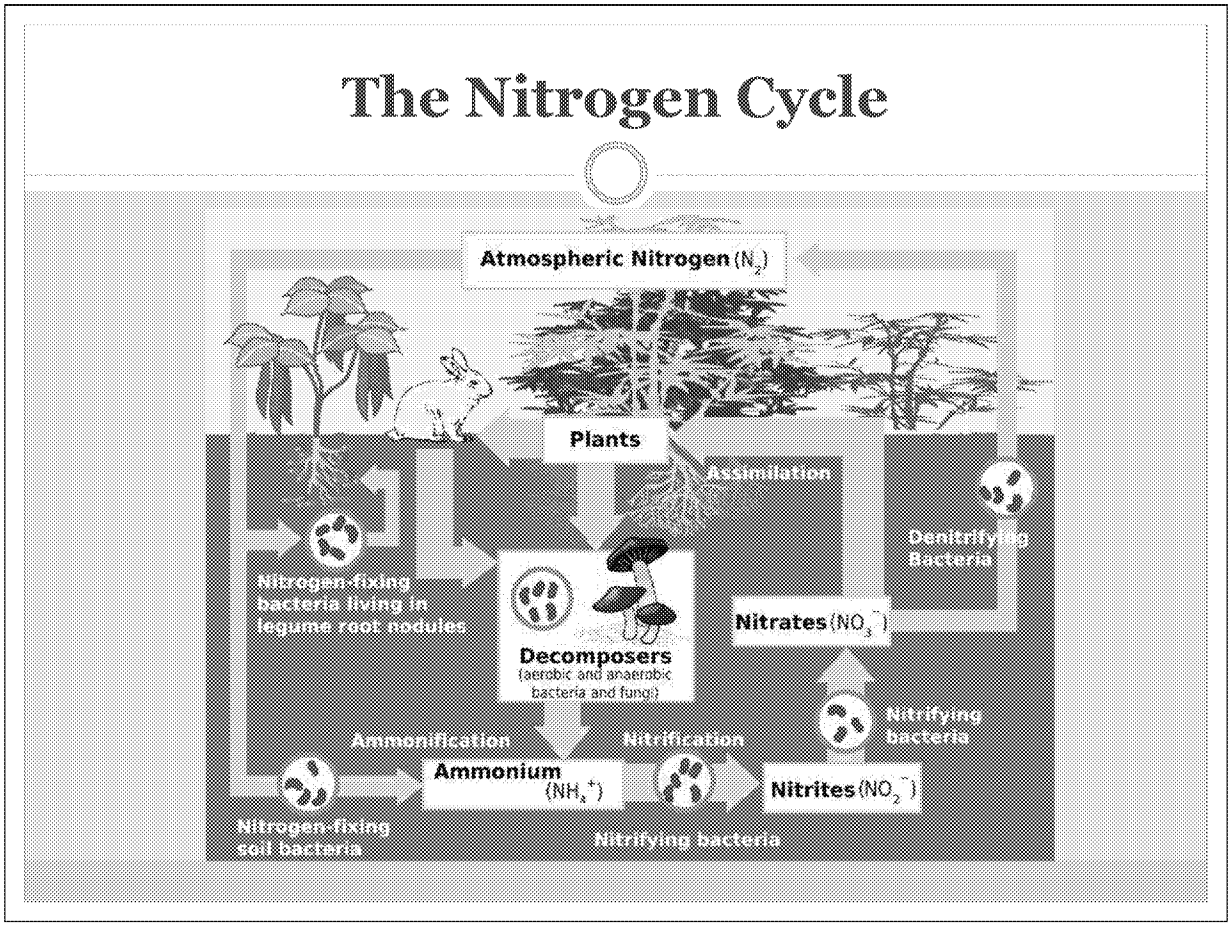
Questions for Case Evaluation

1. What is the most likely cause of this infant's cyanosis?
2. What laboratory tests would help confirm the diagnosis?
3. What steps can you take to prevent a recurrence?
4. What questions will you ask the parents?
5. If well water used to dilute formula is implicated in the cyanosis, what are some possible causes of nitrate contamination?
6. What recommendations can you make to the family?
7. What factors make infants younger than 4 months of age more susceptible to developing methemoglobinemia?
8. Why might some patients with methemoglobinemia not respond to treatment with methylene blue?

Methylene blue increases the NADPH route of conversion of methemoglobin to hemoglobin. There is a deficiency of NADPH in patients with G6PD deficiency so methylene blue is a relative contraindication. These patients may respond to hyperbaric oxygen. Exchange transfusions are appropriate in life threatening cases. Other possible treatments include hydration and administration of sodium bicarbonate in the child who has diarrhea, is dehydrated and acidotic. In cases of chronic toxicity administration of ascorbic acid and vitamin may be effective.

What are Nitrates & Nitrites?

- These are inorganic ions that are part of the nitrogen cycle. They are found in nature
- Microbial action in soil or water decomposes wastes containing organic nitrogen into ammonia, which is then oxidized to nitrite and then nitrate.
- Sources include rodenticides, fertilizers, human and animal wastes
- Nitrate readily passes from the soil into the groundwater



Courtesy of the EPA

Nitrates in Groundwater

- *Too much of a good thing*
- Shallow, rural domestic wells are those most likely to be contaminated with nitrates
- The EPA estimates that 2.4% of private wells nationally exceed the nitrate standard
- In the most recent Lower Yakima Valley study between 12% and 20% of private wells exceeded the nitrate standard
- The standard is 10 mg/L Nitrate – N (10 ppm) or 1 mg/L nitrite – N (1 ppm)

Conversion Factors

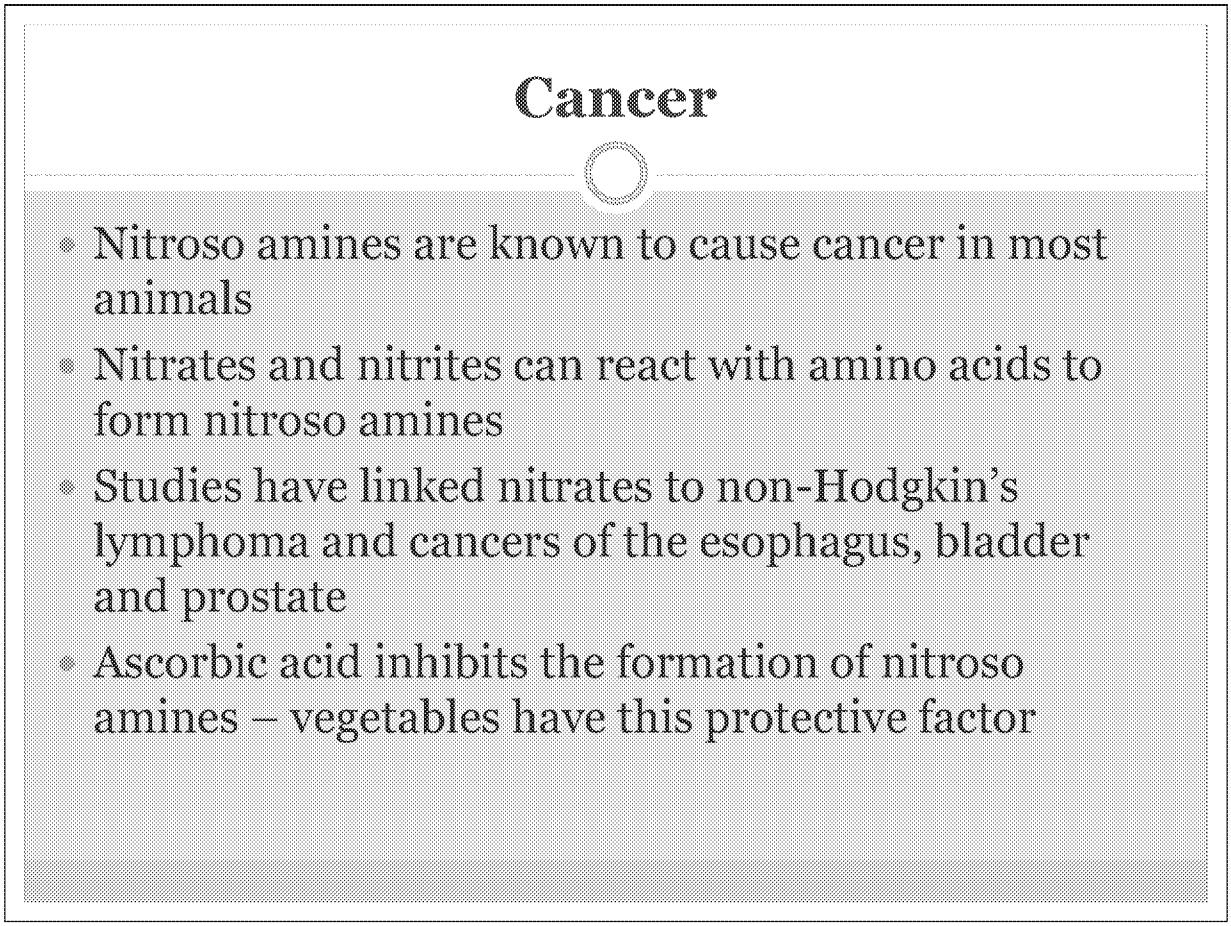
- 1 mg/l as Nitrate = 0.226 mg/l as Nitrate-Nitrogen
- 1 mg/l as Nitrite = 0.304 mg/l as Nitrite-Nitrogen
- MCL for Nitrate – N = 10 mg/L (or 10 ppm)
- MCL for Nitrite – N = 1 mg/L (or 1 ppm)
- MCL for Nitrate = 44 mg/L
- MCL for Nitrite = 3.3 mg/L

Who Is At Risk?

- Infants younger than 6 months and especially younger than 4 months who are given formula diluted with water from private wells
- People with G6PD Deficiency
- People with impaired GI tracts
- People who are immunocompromised
- Women who are pregnant, especially after the 30th week – Increased risk for spontaneous abortion, pre-term delivery, & pre-eclampsia
- Neonates are at risk for intrauterine growth delay, cardiac defects, CNS defects & SIDS

About the Anemic Patient

- Methemoglobin (MHg) is generally expressed as a percent of total hemoglobin
- A patient with a MHg level of 20% and total hemoglobin of 15 g/dL still has 12 g/dL of functioning hemoglobin
- A patient with a MHg level of 20% and a total hemoglobin level of 8 g/dL has only 6.4 g/dL of functioning hemoglobin

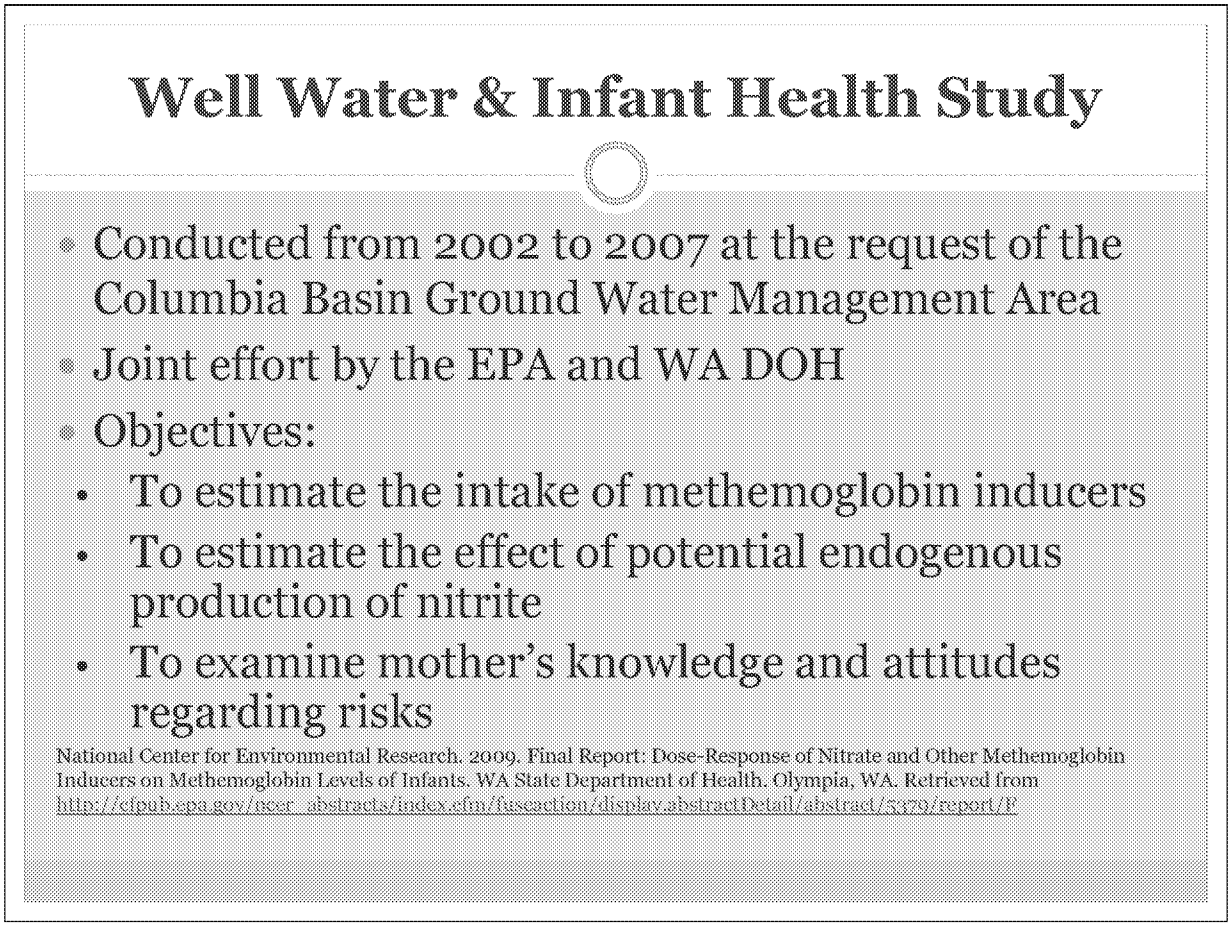


In this country manufacturers of cured meats are required to add ascorbic acid to their products because they contain both amines and sodium nitrite. Pregnant women are told not to eat hot dogs due to a risk of some cancers in the neonate. Many of the studies on nitrates and cancer are equivocal. There is a lot of research to be done.

Epidemiology of Methemoglobinemia

- The first reported case in an infant due to ingestion of nitrate in water occurred in 1945
- In the following 25 years, about 2,000 cases were reported worldwide; about 10% resulted in death
- Sporadic cases and occasional fatalities continue
- Between 1988 and 1994, 10 Washington children were hospitalized with methemoglobinemia
- In the 1990's, during a five year period, physicians in six south central WA counties recalled 7 cases
- Methemoglobinemia is not reportable in our state

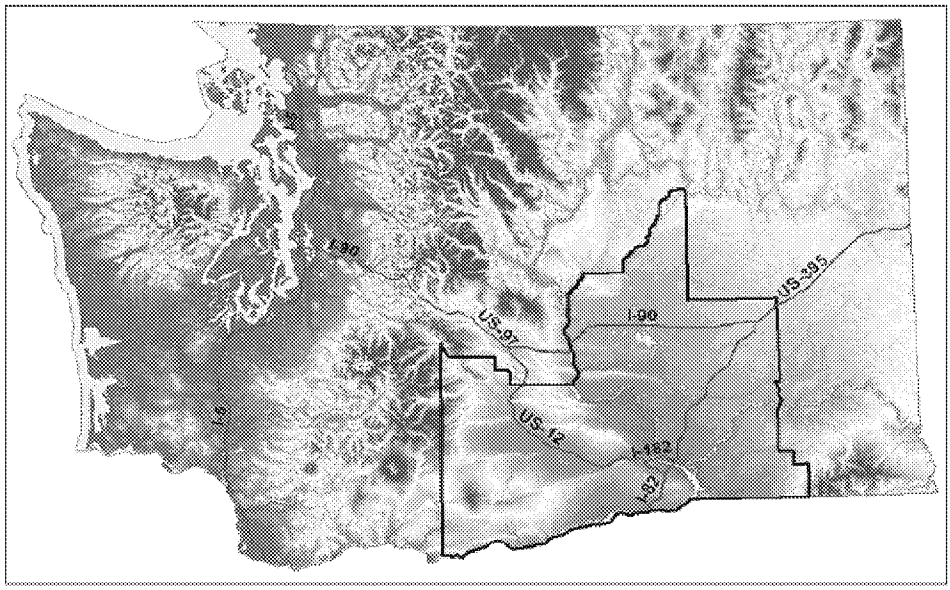
There are startling cases of acute poisoning due to ingestion of cleaning solvents. This has occurred in humans and in animals. In nursing school I first learned about this in the case of "Twelve Blue Men" in which these homeless men became sick after drinking water contaminated with boiler fluid. During the 1990's there was an incident in the southwest in which a herd of wild horses died after drinking water that had been polluted when workers let waste from cleaning aircraft pollute the surface water near a remote airfield. Outbreaks in animals are well known. This summer midwestern cattlemen began testing the corn they fed their animals because drought conditions caused nitrate levels to increase in the dehydrated stalks. Human cases of Methoglobinemia are probably under reported



There are scientists who question the current MCL for nitrates in drinking water and believe that endogenous production of nitrates/nitrites due to bacterial infection and diarrhea may be a more important factor. In 2004 this question arose at an international symposium on drinking water and health. Experts proposed a need for further research. Jim VanDerslice from the WA DOH participated and he conducted this half million dollar study in our state.

Well Water & Infant Health Study

Figure 1. Study area, Washington State



This is a map of the study area: Grant, Adams, Benton, Franklin, Yakima, Walla Walla, and Klickitat Counties. This area has fluctuating elevated levels of nitrate in water primarily due to agricultural activities over the past hundred years

National Center for Environmental Research. 2009. Final Report: Dose-Response of Nitrate and Other Methemoglobin Inducers on Methemoglobin Levels of Infants. WA State Department of Health. Olympia, WA. Retrieved from http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/5379/report/F

Study Design

- Community-based cross-sectional cohort study
- Infants 6 months of age or younger whose families were not served by community water supplies
- 20,276 births, 1738 met criteria, 558 completed the study and 166 partially completed
- Home visits assessed demographics, health, water, diet and parent's understanding of risks
- Heel stick blood samples from infants for MHb
- Analysis of drinking water for nitrates, copper, chloride, and bacteria
- Multi-variable analyses were carried out using linear regression

Demographics

- English (54.7%) was the most common language
- Spanish (44.5%) was the second most common language
- 24% of those who spoke English also spoke Spanish
- 63.5% reported Hispanic ethnicity
- 32% reported White ethnicity
- 3% reported Native American ethnicity
- The Yakama Reservation was not included in the study

National Center for Environmental Research. 2009. Final Report: Dose-Response of Nitrate and Other Methemoglobin Inducers on Methemoglobin Levels of Infants. WA State Department of Health. Olympia, WA. Retrieved from http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/5379/report/F

Current Illnesses in Study Infants

- 9.7% had a fever, vomiting or diarrhea up to and including the day of the interview
- 29% had a "runny nose"
- 12.4% had been "fussy"
- 9.7% had used medications
- 3.2% had used meds with benzocaine

There is a potential for methemoglobinemia due to benzocaine use. Because the percentage was so small the study results were inconclusive in this area.

National Center for Environmental Research. 2009. Final Report: Dose-Response of Nitrate and Other Methemoglobin Inducers on Methemoglobin Levels of Infants. WA State Department of Health. Olympia, WA. Retrieved from http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/5379/report/F

Water Quality

- Assessed kitchen faucets, water pitchers, refrigerator taps, filtered faucets, bottled water and large bottled water
- Tap water samples had the highest level of nitrates
- Mean tap water level was 3.5 mg/L of Nitrate – N
- 8.6% of the samples had Nitrate – N levels > 10 mg/L
- The highest tap water level was 35.6 mg/L

VanDerslice found that bottled water often contained nitrates at levels higher than that found in pristine water or > 1 mg/L

Bacteriological Quality

- 38.5% of the tap water samples were positive for coliform bacteria
- 2.8% were positive for E. Coli
- 32.2 % of filtered water samples were positive for coliform bacteria
- 2.3 % of filtered water samples were positive for E. coli

It is interesting to note how little effect filtering has on bacteria. Filtering with charcoal likewise does not remove nitrates. Reverse osmosis is necessary to accomplish this.

National Center for Environmental Research. 2009. Final Report: Dose-Response of Nitrate and Other Methemoglobin Inducers on Methemoglobin Levels of Infants. WA State Department of Health. Olympia, WA. Retrieved from http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/5379/report/F

Infant Feeding Regimes

- 23.9% were exclusively breast fed
- 31.6% received only formula
- 69.6% received formula and other
- 58.9% received water
- 18.2% received solid foods
- 3% received juice
- 2.1% received carrots or squash
- 0.4% received pedialyte

Nitrate Intake

- 9.6% had intakes > 0.2 mg/kg/day
- 4.3% had intakes > 0.5 mg/kg/day (28 infants)
- Intake > 0.5 mg/kg/day was the high intake group
- 4 infants had intakes greater than the RfD of 1.6 mg/kg/day
- The highest intake was 1.9 mg/kg/day
- Only 3 of the 28 infants in the high intake group consumed < 500 ml water per day and all of these infants were consuming water with > 10 mg/L

Bacteria

- 58.9% of the infants were given water
- Within this group 43.8% of the water samples were positive for coliform bacteria and 1.8% were positive for E. coli
- 31.8% of mothers in this group reported boiling water before use
- ***Boiling water increases nitrate levels***

Methemoglobin Levels

- Reported for 537 infants
- 63.5% (341) of infants had levels >1%
- 11.7% (63) of infants had levels >2%
- 2.6% (14) of infants had levels >3%
- Seven infants had levels >4%
- One infant had a level >5%
- None showed frank signs or symptoms of blue baby syndrome which usually begin at levels > 10%
- Methemoglobin levels are known to fluctuate

Methemoglobin levels were obtained from 558 infants. Some parents refused to allow blood draws. In 21 cases the co-oximeter calibration was outside parameters. The results are reported for 537 infants. Some experts consider any level > 1% to be too high while others choose > 2%. It is well documented that individual methemoglobin levels vary in a 24 hour period.

National Center for Environmental Research. 2009. Final Report: Dose-Response of Nitrate and Other Methemoglobin Inducers on Methemoglobin Levels of Infants. WA State Department of Health. Olympia, WA. Retrieved from http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/5379/report/F

Risk Factors

- 60.7% of those with high nitrate intakes also had total coliform water compared to 22.8% with low intakes
- Those in the high nitrate group were half as likely to have diarrhea (3.6% vs. 6.2%)
- Those in the high nitrate intake group were more likely to have their water boiled (46.4% vs. 17.4%)
- None of the exclusively breast fed infants were in the high intake group
- None of the infants fed carrots were sick

Relationships

- Four risk factors were associated with MHb levels above 3%
- High nitrate intake (OR = 5.9, p = 0.003)
- High nitrate intake including carrots (OR=4.1, p=0.026)
- Consumption of E. coli positive water (n=7) (OR=10.0, p=0.014)
- Age < 3 months (OR=3.1, p=0.05)

Parental Perceptions & Attitudes

- 48.4% felt that their tap water was not safe for the baby to drink
- 16% felt their tap water was safe only because it had been boiled
- 33.9% felt that their tap water was not safe for anyone to drink
- 5% thought that someone in their home had been ill because of tap water
- 48.2% reported having their well water tested

This study did not ask whether parents were home owners or renters which may be a factor in having water tested. Yakima County does not provide well water testing and the $90 cost for both nitrates and bacteria is the responsibility of the well owner. Economic status was not assessed in the study but we do know that poverty levels are high.

National Center for Environmental Research. 2009. Final Report: Dose-Response of Nitrate and Other Methemoglobin Inducers on Methemoglobin Levels of Infants. WA State Department of Health. Olympia, WA. Retrieved from http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/5379/report/F

Irrigated Agriculture – Yakima County

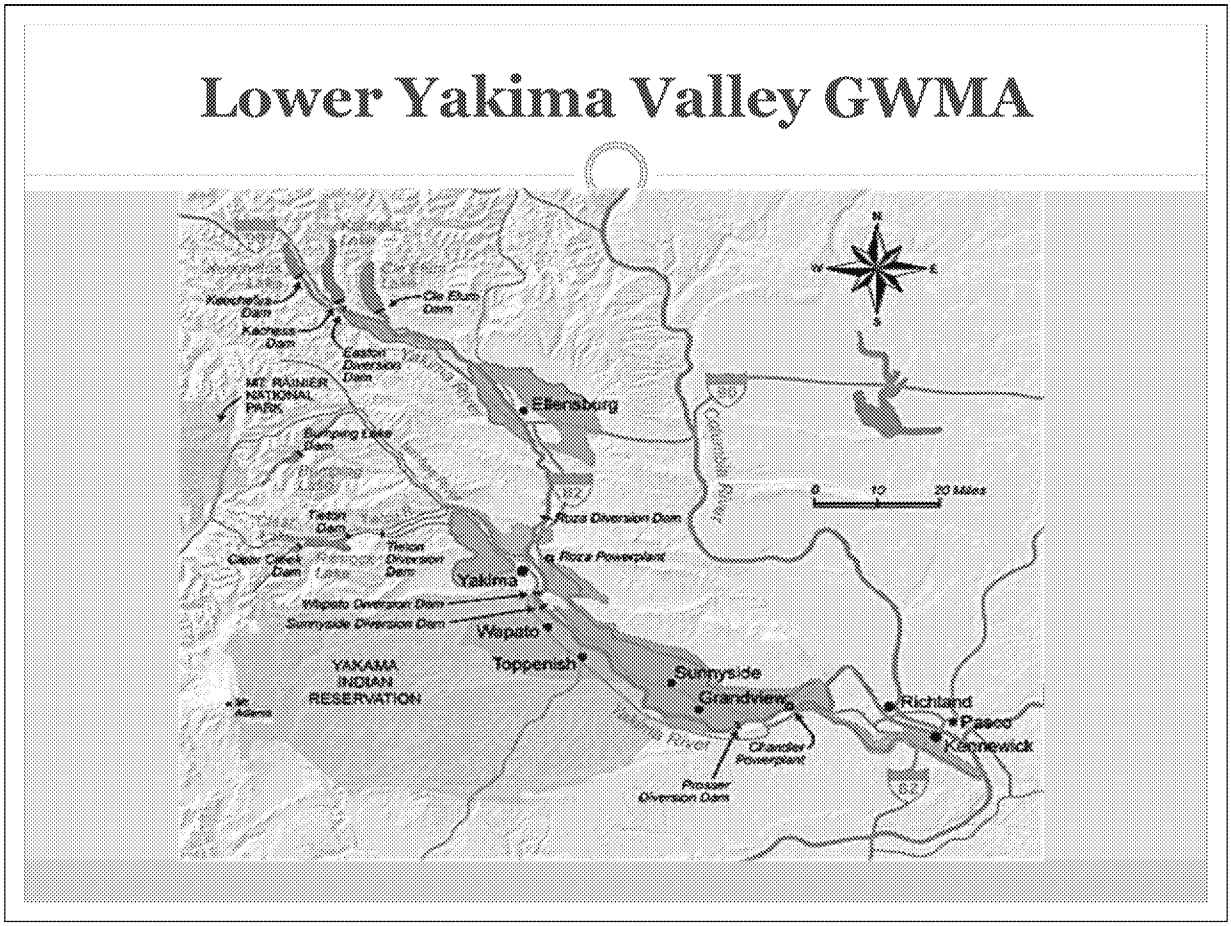
This is what the Lower Yakima Valley looks like

Lower Yakima Valley GWMA

- For many years there have been concerns about water quality in Yakima County
- In 2001 – 2002, as part of a law suit settlement a study in the area showed increased nitrate levels in the lower valley compared to the upper valley
- In 2008 the Yakima Herald Republic ran a series entitled, “Hidden Wells, Dirty Water”
- The EPA responded by conducting open meetings and designating the area an Environmental Justice Community

Lower Yakima Valley GWMA

- The EPA Preliminary Assessment Report estimated that over 2,000 people in the lower valley are exposed to nitrate above the maximum contaminant level (MCL) through their drinking water
- Population of area is 71,400, 34% of these residents are on private wells, and about 12% of private wells exceed the nitrate MCL
- A Ground Water Management Area was created in 2012 under authority of WAC 173-100 to address the problem

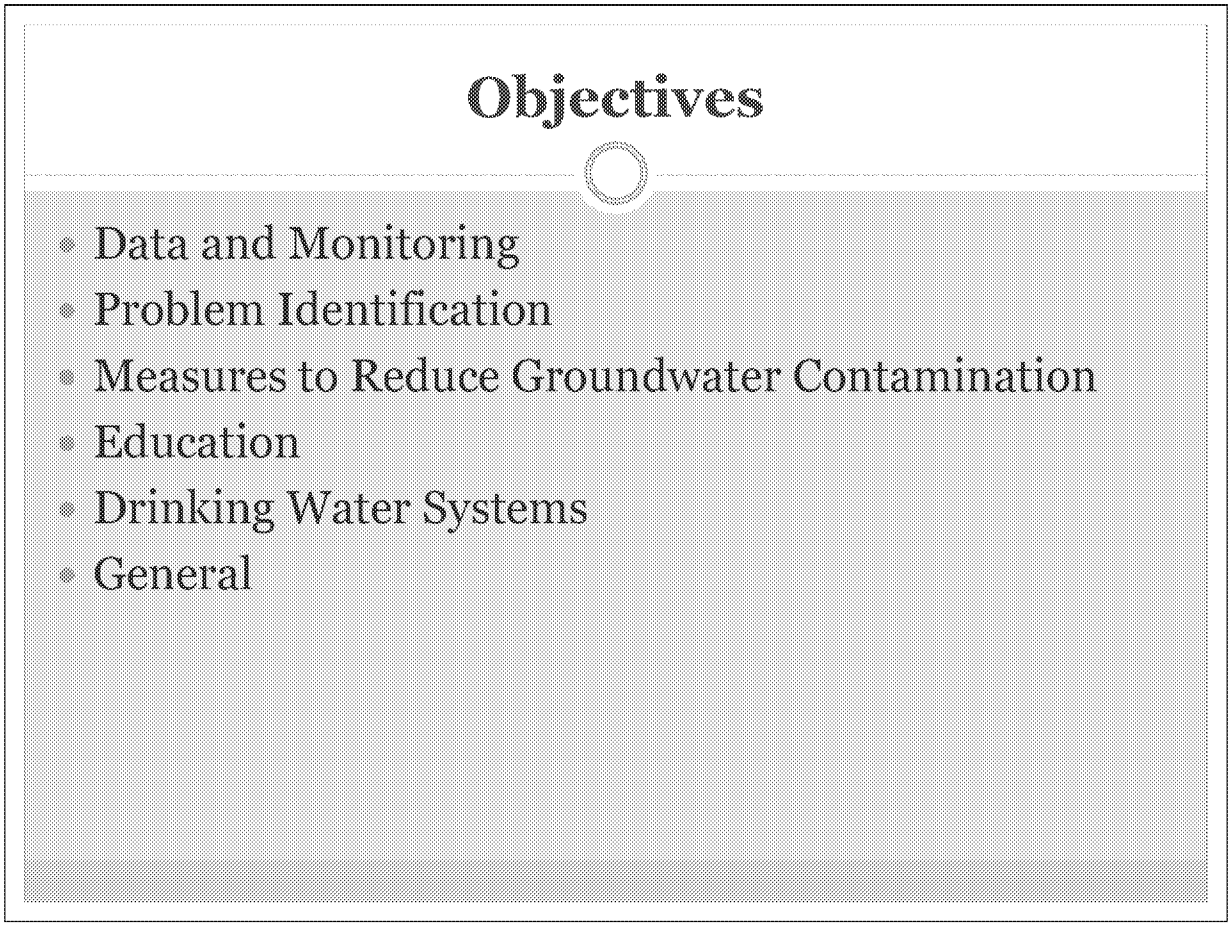


Courtesy of the U.S. Bureau of Reclamation

Lower Yakima Valley GWMA

- Funded and authorized by the WA State Dept. of Ecology
- Administered by Yakima County
- A consortium of stakeholders – Agencies, Local Government, Community, Agriculture & Environment with 22 representatives
- The Yakama Nation sends a voting representative to meetings
- Two years to discuss and organize, followed by implementation of plan

GWMAs are often long term projects. The Columbia Basin GWMA has been in place for 15 years. There are GWMAs in Oregon that have functioned for 20 years



Education is a serious problem. Many of the people who live in the area are marginalized. There are those who do not believe there is a problem. In 2011, Yakima undertake a project to install reverse osmosis devices in 300 homes. Response was poor. One man stated, "I have been drinking the water for 60 years and I am alright." Others stated, "It is my landlord's problem." Ultimately only 166 devices were installed and the county had to return $100,000 of funding.

EPA Study - Published Sept. 2012

- Evaluated water for nitrates/nitrites and over 200 known contaminants:
  - * Nitrates/Nitrites
  - * Animal and human hormones
  - * Major ions, trace elements & trace organics
  - * Bacteria
  - * Pharmaceuticals
- Tested above and below three known sources:
  - * Dairies and feedlots
  - * Irrigated agriculture (only down gradient)
  - * Septics and bio solids

Sources of Nitrate Contamination

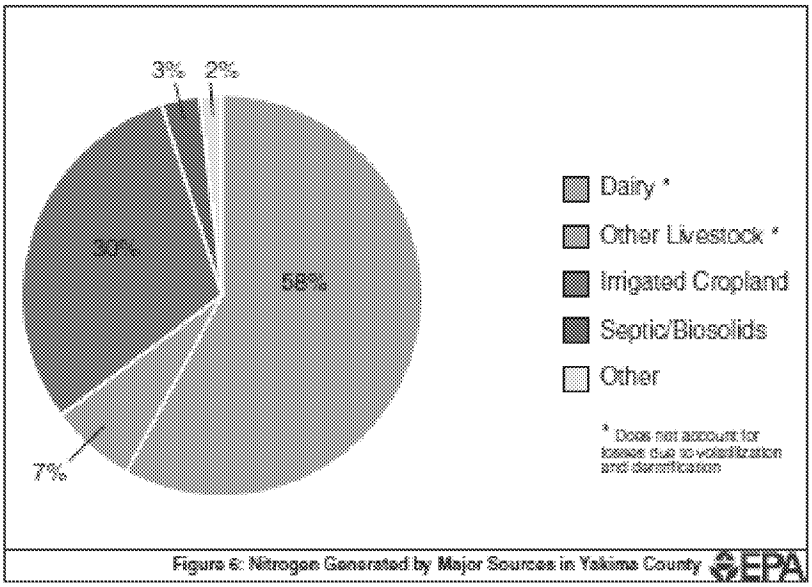
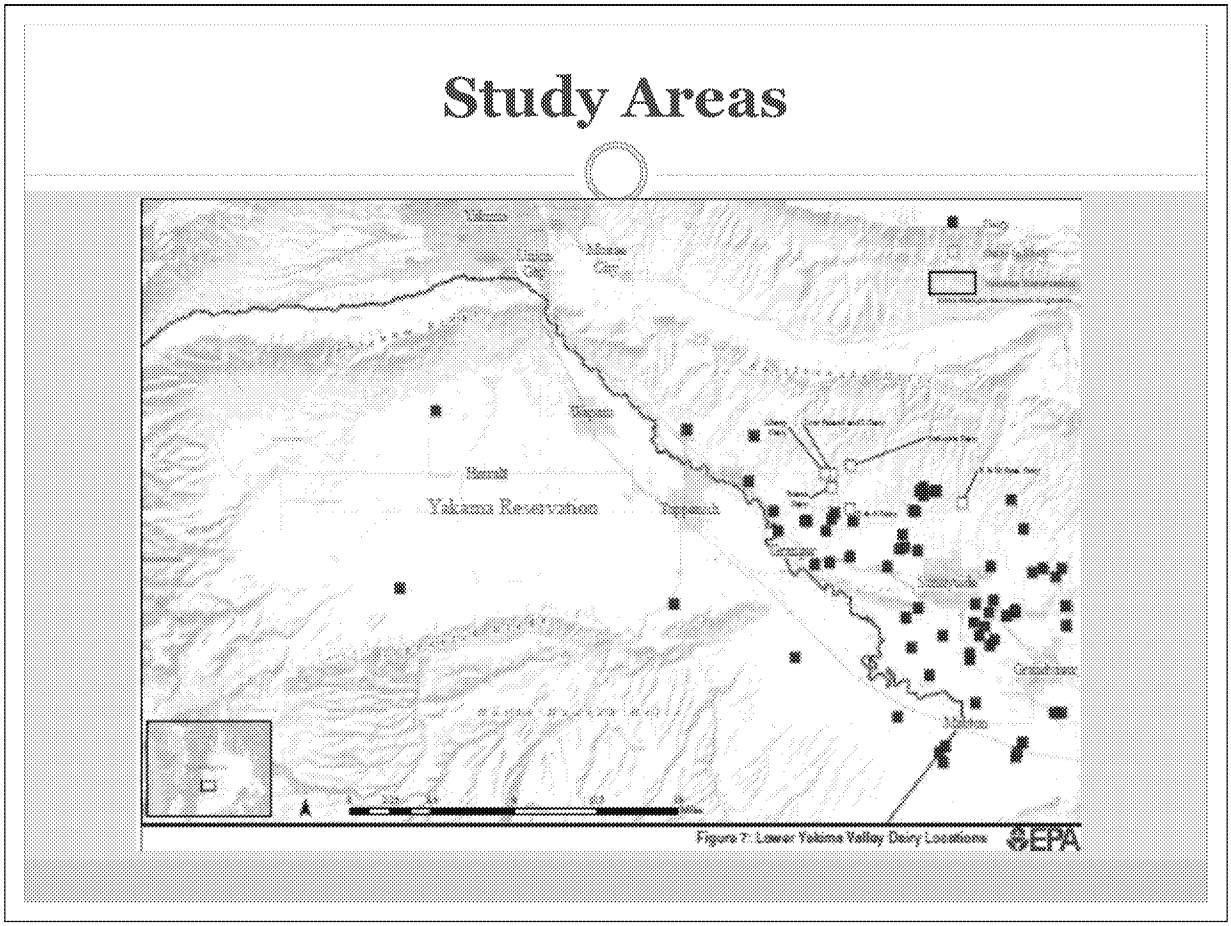


Figure 6: Nitrogen Generated by Major Sources in Yakima County EPA



There are about 70 dairies in this area with an estimated 120,000 dairy cows. This does not count other cattle and calves that bring the total to about 230,000 in a 340 square mile area. This equates to a density of 676 cows per square mile. The density of dairy cows is 353 per square mile. The human population is 210 people per square mile. Grown cows produce 20 times more feces than humans and modern dairy operations collect this product in huge unlined and uncovered lagoons. Find available land for application is a challenge.

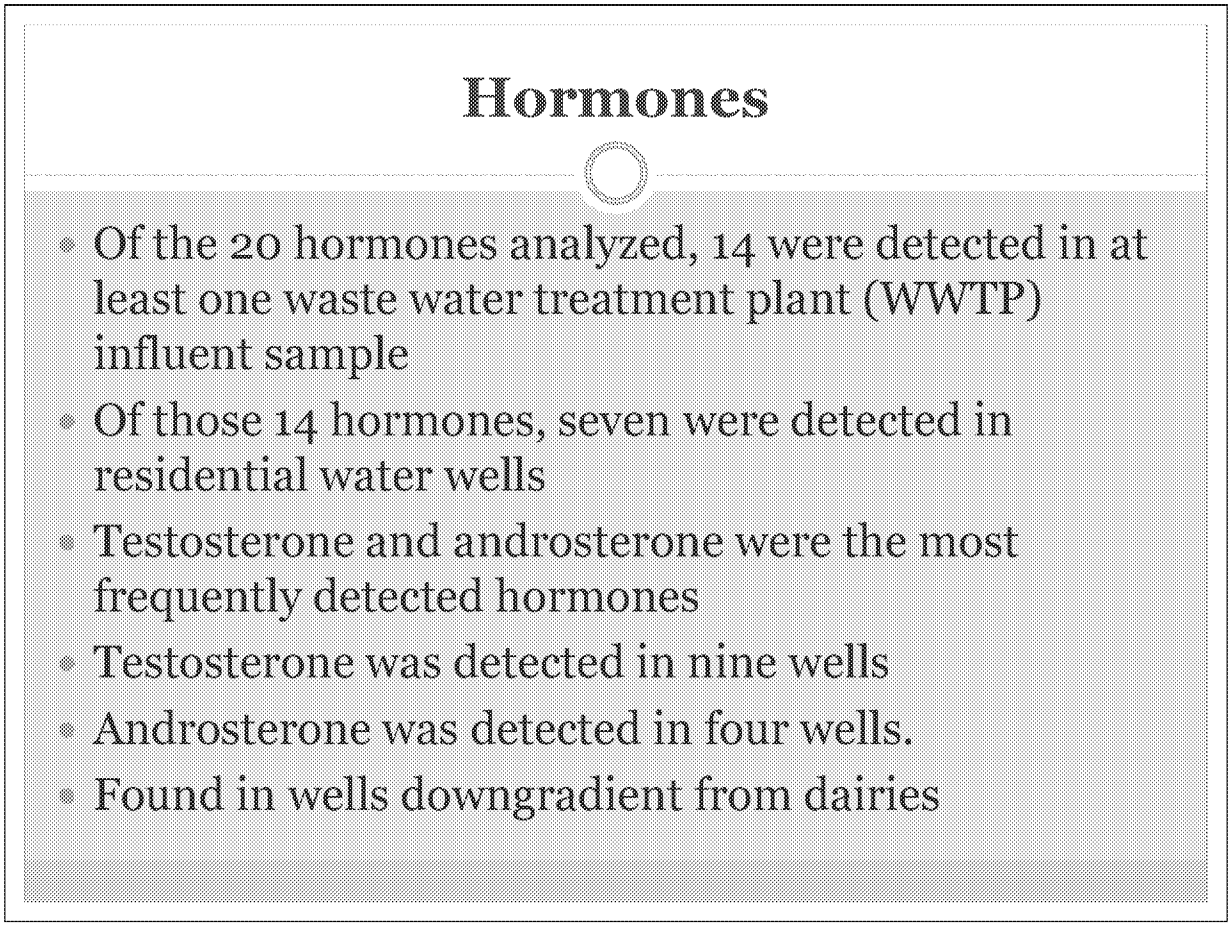
Study Highlights

- Well water testing was performed for 29 wells – 26 residential wells and 3 dairy supply wells
- Many of the chemical and microbial contaminants evaluated were not found
- For example – the only pesticides detected in significant amounts were Atrazine and Bentazone
- There were no detections of fecal coliform in the residential wells
- DEHP was detected in four residential drinking water wells and DEET was detected in one

Atrazine and bentazone remain in the groundwater for long periods of time. They have serious effects and application is now closely monitored. Levels were well below safety limits.
Interestingly DEHP (also called phthalates) was found in significant concentrations in wells upstream from dairies

Pharmaceuticals

- Sulfamethazine (used for cattle, poultry, and swine) was detected in two residential water wells
- Sulfamethoxazole (used for people) was detected in one residential drinking water well
- Tetracycline (used for people, cattle, and several other animals) detected in six residential wells.
- There were 10 additional veterinary pharmaceuticals detected in residential water wells, primarily
  - *Monensin was detected in nine residential wells
  - * Virginiamycin detected in four residential wells



Given both testosterone and androsterone are natural sex hormones it is possible they came from septic systems in proximity to the residential water wells, but these compounds were also detected in wells downgradient of the dairies.

Nitrates

- Nitrate levels were significantly higher in wells downgrade from dairies
- Wells upgrade from dairies had concentrations of Nitrate-N that were < 1 mg/L
- Downgrade levels ranged from 12.8 to 51.9 mg/L
- Wells downgrade from irrigated fields had levels that ranged from 13.8 to 71.9 mg/L of Nitrate-N
- Wells downgrade from septic systems ranged from 15 to 38.2 mg/L
- Isotopic analyses show nitrates from animal sources in 6 of 7 samples and chemical fertilizers in 1 of 7

The GWMA Mission

"The primary long-term goal of the GWMA is to reduce concentrations of nitrate in groundwater to below Washington State drinking water standards. Reductions in nitrogen loading will be demonstrated within 5 years. Progress towards identifying and reducing the sources of groundwater contamination will be evaluated by 2013 and shared with the public."

Thank You for Participating

Questions & Comments

- Please visit www.friendsoftoppenishcreek.org
- Please contact jean.mendoza@wildblue.net
- Please visit http://www.yakimacounty.us/gwma/

References

- Agency for Toxic Substances and Disease Registry. (2001). *Case Studies in Environmental Medicine Nitrate/Nitrite Toxicity*. Department of Health & Human Services. Atlanta, GA. Retrieved from http://www.atsdr.cdc.gov/csem/nitrate/docs/nitrate_nitrite.pdf
- Environmental Environmental Protection Agency (2010) Yakima Valley Groundwater Contamination: Summary of EPA Sampling Activities. Retrieved from http://yosemite.epa.gov/r10/water.nsf/bb9c63e62d1ae1f8882564f4007da918/1ea7e8c810acb7578825764700077b0e3/$FILE/Yakima%20Valley%20EPA%20Sampling%20Summary%20June%2022%202010.pdf

References

- National Center for Environmental Research. 2009. Final Report: Dose-Response of Nitrate and Other Methemoglobin Inducers on Methemoglobin Levels of Infants. WA State Department of Health. Olympia, WA. Retrieved from http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/5379/report/F
- Pacific Groundwater Group (2011) Request for identification Lower Yakima Valley Groundwater Management Area. WA State Department of Ecology. Retrieved from www.yakimacounty.us/NitrateProgram/English/Docs/Lower%20Yakima%20GWMA%20Request%20For%20Identification%20FINAL.pdf

References

- Secret History X (nd) The Martin Fugate Family. Retrieved from http://www.secrethistoryx.com/tag/methemoglobinemia/
- U.S. Environmental Protection Agency. 2007. *Nitrates and Nitrites TEACH Chemical Summary.* Retrieved from http://www.epa.gov/teach/chem_summ/Nitrates_summary.pdf
- U.S. Environmental Protection Agency (2012) Preliminary data Lower Yakima Valley well testing. Retrieved from ftp://ftp.epa.gov/reg10ftp/sites/yakima/groundwater_data/

References

- Ward, M.H., deKok, T.M., Levallois, P., Brender, J., Gulis, G., Nolan, B.T., and VanDerslice, J. (2004) *Workgroup report: drinking-water nitrate and health – recent findings and research needs.* Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1310926/pdf/ehp0113-001607.pdf
- Washington State Dept. of Ecology (2010) Lower Yakima Valley groundwater quality: preliminary assessment and recommendations document. Retrieved from https://fortress.wa.gov/ecy/publications/publications/1010009.pdf

References

- Word Press (nd) Kentucky Blue People. Retrieved from http://kentuckybluepeople.wordpress.com/the-fugate-family-paige-disponette
- Yakima County (2011) Nitrate Treatment Pilot Program – Final Report. Retrieved from http://www.yakimacounty.us/nitrateprogram/english/Docs/Nitrate%20Treatment%20Pilot%20Program.pdf

Sources for Further Reading

- Agency for Toxic Substances and Disease Registry (2005) Case studies in Environmental Medicine: Nitrate/Nitrite Toxicity – Course WB 1107 Available at http://www.atsdr.cdc.gov/csem/nitrate/docs/nitrate_nitrite.pdf
- Avery AA. Infantile methemoglobinemia: reexamining the role of drinking water nitrates. Environ Health Perspect 1999;107(7):583–6.
- Centers for Disease Control and Prevention. A survey of the quality of water drawn from domestic wells in nine Midwest states. Atlanta: US Department of Health and Human Services; 1995.
- Berlin G, Brodin B, Hilden J. Acute dapsone intoxication: a case treated with continuous infusion of methylene blue, forced diuresis, and plasma exchange. J Toxicol Clin Toxicol 1985;22:537–48.

Sources for Further Reading

- Croen, LA, Todoroff K, Shaw GM. Maternal exposure to nitrate from drinking water and diet and risk of neural tube defects. Am J Epidemiol 2001;153:325–31.
- Dusdieker LB, Getchell JP, Liarakos TM, Hausler WJ, Dungy CI. Nitrate in baby foods: adding to the nitrate mosaic. Arch Pediatric Adolesc Med 1994;148: 490–94.
- Dusdieker LB, Dungy CI. Nitrates and babies: A dangerous combination. Contemp Pediatr 1996;13(11):91–102.
- Eichholzer M., Gutzwiller F. Dietary nitrates, nitrites, and *N*-nitroso compounds and cancer risk: a review of the epidemiologic evidence. Nutr Rev 1998; 56:95–105.

Sources for Further Reading

- Fan AM, Steinberg VE. Health implications of nitrate and nitrite in drinking water: An update on methemoglobinemia occurrence and reproductive and development toxicity. Regul Toxicol Pharmacol 1996;23(11):35–43.
- Fewtrell, L (2004) Drinking-Water Nitrate, Methemoglobinemia, and Global Burden of Disease Environmental Health Perspectives 112:1371-1374. Doi:10.1289/ehp.7216 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1247562/pdf/ehp0112-001371.pdf
- Gebara B., Goetting MM. Life-threatening methemoglobinemia in infants with diarrhea and acidosis. Clin Pediatr 1994;33:370–3.
- Johnson CJ, Kross BC. Continuing importance of nitrate contamination of groundwater and wells in rural areas. Am J Ind Med 1990;18(4): 449–56.
- Knobeloch L, Salna B, Hogan A, Postle J, Anderson H. Blue babies and nitrate-contaminated well water. Environ Health Perspect 2000; 108(7)

Sources for Further Reading

- Kross BC, Ayebo AD, Fourtes LJ. Methemoglobinemia: nitrate toxicity in rural America. Am Fam Physician 1992;46:183–88
- Lebby T, Roco JJ, Arcinue EL. Infantile methemoglobinemia associated with acute diarrheal illness. Am J Emerg Med 1993;11:471–2.
- Lundberg JO, Weitzberg E, Cole JA, Benjamin N. Nitrate, bacteria and human health. Nat Rev Microbiol 2004;2(7):593–602
- Mackerness CW, Keevil CW. Origin and significance of nitrite in water. In: Hill MJ, editor. Nitrates and nitrites in food and water. Chichester, England: Ellis Horwood; 1991.
- McKnight GM, Duncan CW, Leifert C, Golden MH. Dietary nitrate in man: Friend or foe? Br J Nutr 1999; 81(5):349–58.
- Mansouri A, Lurie AA. Concise review: Methemoglobinemia. Am J Hematol 1993;42:7–12.

Sources for Further Reading

- Mensinga TT, Speijers GJA, Meulenbelt J. Health implications of exposure to environmental nitrogenous compounds. Toxicol Rev 2003;22(1):41–51.
- National Research Council, Committee on Toxicology. Nitrate and nitrite in drinking water. Washington, DC: National Academies Press; 1995.
- Price D. Methoglobinemia. In: Goldfrank LR, Flomenbaum NE, Lewin NA, Weisman RS, Howland MA, Hoffman RS, editors. Goldfrank's toxicologic emergencies. 6th ed. Old Tappan, NJ: Appleton & Lange 1998. p. 1507–23.
- Reynolds KA. The prevalence of nitrate contamination in the United States. Water Conditioning and Purification 2002; 44(1). Available from URL: http://www.wcponline.com/ArchiveNewsView.cfm?pkArticleID=1330&AT=T

Sources for Further Reading

- Saito T, Takeichi S, Osawa M, Yukawa N, Huang X-L. A case of fatal methemoglobinemia of unknown origin but presumably due to ingestion of nitrate. Int J Legal Med 2000;113(3):164–7.
- Sanchez J., Benito-Fernandez J, Mintegui-Raso S. Methemoglobinemia and consumption of vegetables in infants. Pediatrics 2001;107(5):1024–8.
- Shearer LA, Goldsmith JR, Young C, Kearns OA, Tamplin BR. Methemoglobin levels in infants in an area with high nitrate water supply. Am J Public Health 1972;62(9):1174–80.
- Shuval HI, Gruener N. Epidemiological and toxicological aspects of nitrates and nitrites in the environment. Am J Public Health 1992; 62(8):1045–52.

Sources for Further Reading

- Spontaneous abortions possibly related to ingestion of nitrate-contaminated well water-LaGrange County, Indiana, 1991–1994. MMWR 1996;45:569–72.
- Tabacova S, Balabaeva L, Little RE. Maternal exposure to exogenous nitrogen compounds and complications of pregnancy. Arch Environ Health 1997;52(5):341–7.
- Tricker AR, Preussmann R. Carcinogenic *N*-nitrosamines in the diet: occurrence, formation, mechanisms and carcinogenic potential. Mutat Res 1991;259:277–89.
- US Environmental Protection Agency. Consumer factsheet on: nitrates/nitrites. Washington, DC: US Environmental Protection Agency; 2004. Available from URL: http://www.epa.gov/safewater/dwh/c-ioc/nitr

Sources for Further Reading

- US Environmental Protection Agency. Integrated Risk Information System (IRIS) database. Nitrate (CASRN 14797-55-8). Washington, DC: US Environmental Protection Agency. 2002. Available at URL: http://www.epa.gov/iris
- US Geological Survey. The quality of our nation's waters: nutrients and pesticides. Circular 1225. Reston, VA: US Department of the Interior; 1999.
- Van Loon AJ, Botterweck AA, Goldbohm RA, Brants HA, van Klaveren JD, van den Brandt PA. Intake of nitrate and nitrite and the risk of gastric cancer: a prospective cohort study. Br J Cancer 1998; 78:129–35.
- Walker R. The metabolism of dietary nitrites and nitrates. Biochem Soc Trans 1996;24(3):780–5.

Sources for Further Reading

- Ward MH, Mark SD, Cantor KP, Weisenburger DD, Correa-Villasenor A, Zahm SH. Drinking water nitrate and the risk of non-Hodgkin's lymphoma. Epidemiology 1996; 7(5):465–71.
- WA State Dept. of Ecology (2010) Lower Yakima Valley Groundwater Quality – Preliminary Assessment and Recommendations Document. Retrieved from http://www.ecy.wa.gov/pubs/1010009.pdf
- WA State Dept. of Health (2010) Nitrate in Drinking Water – Questions and Answers (English) Retrieved from http://www.doh.wa.gov/ehp/dw/Publications/331-214.pdf
- WA State Dept. of Health (2010) Nitrate in Drinking Water – Questions and Answers (Spanish) Retrieved from http://www.doh.wa.gov/ehp/dw/Publications/331-214s.pdf

Sources for Further Reading

- Wright RO, Woolf AD, Shannon MW, Magnani B. *N*-acetylcysteine reduces methemoglobin in an in-vitro model of glucose-6-phosphate dehydrogenase deficiency. Acad Emerg Med 1998;5(3):225–9.
- Wright RO, Lewander WJ, Woolf AD. Methemoglobinemia: etiology, pharmacology, and clinical management. Ann Emerg Med 1999;34(5):646–56.
- Zeman CL, Kross B, Vlad M. A nested case-control study of methemoglobinemia risk factors in children of Transylvania, Romania. Environ Health Perspect 2002;110(8):817–22.